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Big Sky partnership to bury greenhouse gas in lava rock

Below the plains of the Big Sky states, where the Columbia and Snake rivers wind their way to the Pacific, might lie a geologic answer to one of our most pressing environmental problems: too much carbon dioxide in the air. The greenhouse gas traps heat to contribute to a slow warming of the atmosphere. For humans, who have been pumping carbon out of the earth for the last 200 years, part of the solution might be to finally learn how to do the reverse.

Along with researchers from three Idaho universities, geologists from Idaho National Laboratory in Idaho Falls will test how well the volcanic rocks abundant below the Columbia and Snake river plains store carbon dioxide. Researchers from INL, the University of Idaho, Boise State University, Idaho State University in Pocatello and Battelle Pacific Northwest Division in Richland, Wash., are now making preparations to inject the gas into the subterranean volcanic basalt rock and monitor whether the rock can hold it. This is the largest of several field tests for which the U.S. Department of Energy and private companies awarded $17.9 million to the Big Sky Carbon Sequestration Partnership in June.

Big Sky is one of seven regional coalitions of government, research and industry members across the country. Over the next four years, these groups will conduct field tests to begin to move carbon sequestration from concept to reality.

"Ultimately, what we're trying to do is create the infrastructure for carbon sequestration in this region," says David Shropshire, an engineer at INL and deputy director of the Big Sky partnership. Big Sky lead institution Montana State University in Bozeman will coordinate land-based tests, such as reforestation and crop rotation, to soak up carbon dioxide. Idaho researchers are investigating storage in rock.

In the Big Sky partnership's area, which includes Idaho, Montana, Wyoming, South Dakota and eastern Washington and Oregon, volcanic basalt covers 85,000 square miles, an area equivalent to the state of Idaho. Preliminary calculations by the group show this basalt could store more than 100 billion tons of carbon dioxide-as much as all the coal-burning power plants in the United States produce in 20 years. Worldwide, basalt is found in the enormous Deccan Plateau, encompassing most of central and southern India, and in vast tracts of Siberia. "These formations are huge," Shropshire says. "They could store a lot of carbon."

A Lava Sponge

At first, basalt seemed an unlikely candidate for sequestration. The technique was first envisioned for filling pockets in sedimentary rock, particularly those emptied through extraction of oil and natural gas. Engineers regarded dull, gray basalt as too dense to support injections. On the other hand, they viewed honeycombed sections as "porous, permeable rock that couldn't hold anything," says INL geochemist Travis McLing, the Big Sky partnership's geologic operations manager.

But basalt accumulates in layers, as successive lava outpourings spread out and cool, forming a stack like pancakes, each tens to hundreds of feet thick. The fast-cooled, rubbled tops are full of cracks and gas bubbles; the slow-cooled, dense interiors form impermeable barriers. Using computer models of the rocks' porosity and chemistry, the group reported in 2004 that layered basalts appeared to be well suited for secure, long-term storage.

Now, researchers are preparing to test their theory in the rock. Geologists are getting ready to inject thousands of tons of pressurized carbon dioxide in Western basalt formations. The multimillion-dollar experiment, slated to begin injection in 2007, after all required permits are secured, will trace the fluid through the rocks to monitor how quickly it is dissolved. Scientists will test the air to make sure no carbon dioxide escapes and will lower instruments down the drilling hole to monitor chemical changes.

The project represents the first field test of the feasibility of carbon storage in this type of formation. Elsewhere, field tests to bury carbon in sedimentary rock are building on the petroleum industry's experience with carbon dioxide injections for enhanced oil recovery. "In basalts," McLing says, "there hasn't been anything yet."

Geology on Fast Forward

Lava offers an important long-term advantage over other subterranean storage depots, which include emptied oil and natural-gas pockets, deep saline aquifers and coal seams. Basalt converts carbon dioxide to a harmless salt, a solid that can't escape during an earthquake or other disturbance.

In the experiment, the researchers will compress pure carbon dioxide to form a liquid, which it will then inject more than a half-mile underground. There, the liquid will displace some water, explains Robert Smith, a geochemist at UI and the technical lead for Big Sky's geologic sequestration. Based on their analyses, the researchers expect the carbon dioxide to dissolve over the next few months into the water "like in a can of soda," he says. This mixture will produce a weak acid, roughly the acidity of orange juice. Minerals in the basalt will react with the acid to produce calcium carbonate (limestone, found in seashells), magnesium carbonate (a chalky substance, used by gymnasts and weightlifters to improve their grip) and other solid carbonates.

"It's the same kinds of natural reactions that occur all the time, except that there's so much more carbon dioxide that the reactions are going to occur much, much faster," Smith explains. "You're speeding up naturally occurring processes that take carbon out of the atmosphere."

Other rock types convert carbon dioxide to solid form, but much more slowly. Because volcanic rock is young and reactive, the conversion happens tens to hundreds of times faster than in other types of rock, in just a few centuries. That's a blink of an eye in geologic time.

"These rocks have a large capacity and they react very rapidly," Smith says. "Because the final products are solids, they don't come back to the surface. They're not going to leak out."

Looking Ahead

Big Sky industry partners contributed 20 percent of the $17.9 million grant, the rest coming from the DOE. Many companies are preparing for a future in which carbon emissions from power plants and factories may need to be reduced, says MSU economist Susan Capalbo, the director of the Big Sky partnership. Future power plants, she says, will either offset emissions with agricultural or other land-based projects, or they will sequester the gas underground.

"Zero-based emission technologies imply not that [power plants] won't produce carbon dioxide," Capalbo explains, "but that they will do something with those emissions."

The Big Sky partnership is preparing the way. Geographers at INL have published a computer map of carbon producers, geologic sites and existing pipelines that could be used to transport the gas. In the next phase, they will more fully characterize each potential geologic storage site.

Shropshire explains: "In the future, we can be smarter about where we site power plants, to match up where you're going to put that plant with where you can most effectively be storing its carbon underground."

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